PROC. ENTOMOL. SOC. WASH.
108(2), 2006, pp. 381–388

DESCRIPTION OF THE LARVA OF *GOMPHUS SANDRIUS* TENNESSEN (ODONATA: GOMPHIDAE)

KENNETH J. TENNESSEN

125 N. Oxford St, Wautoma, WI 54982, U.S.A. (e-mail: ktennessen@centurytel.net)

Abstract.—The final stadium larva of *Gomphus sandrius* Tennessen is described based on reared specimens from Tennessee. The larva is distinct from *G. exilis* Selys and *G. lividus* Selys (the only species in the subgenus *Gomphus* sympatric with *G. sandrius*) by the greater width to length ratio of abdominal segment 9 venter (mean 1.82, range 1.69–1.96 in *G. sandrius* vs. mean 1.43, range 1.23–1.57 in *G. lividus* and mean 1.40, range 1.26–1.52 in *G. exilis*). It differs further from *G. lividus* in the narrower prementum (2.40–2.90 mm vs. 3.00–3.75 mm and shorter antennal segment 3 (1.15–1.35 mm vs. 1.50–1.90 mm). The larva of *G. sandrius* is most similar to the allopatric *G. graslinellus* Walsh, but antennal segment 3 is shorter (*G. sandrius*: mean 1.25 mm, range 1.15–1.35 mm; *G. graslinellus*: mean 1.45 mm, range 1.35–1.55 mm).

Key Words: Odonata, Gomphidae, *Gomphus*, larva, Tennessee

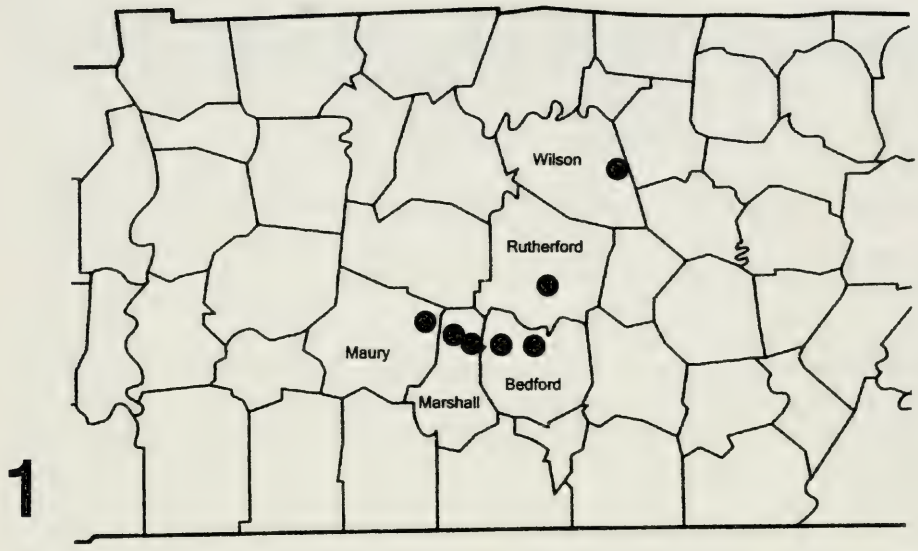
Gomphus sandrius Tennessen is a rare dragonfly restricted in geographic range to south-central Tennessee (Dunkle 2000, Donnelly 2004). There are seven known localities in five contiguous counties in the Central Basin (Fig. 1). Bick (2003), who listed Alabama (Colbert Co.) in error, rated the species "critically imperiled" (Natural Heritage category G1); only 3 of the 27 odonate species considered to be "at-risk" in the United States were rated as G1. For possible future conservation efforts, ability to distinguish the larva of *G. sandrius* from its congeners is critical.

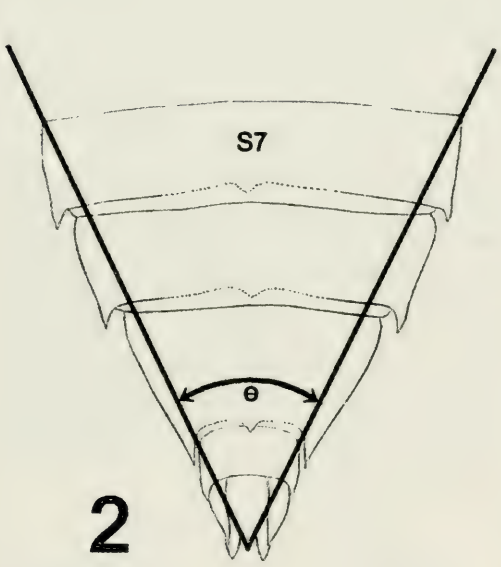
Gomphus sandrius belongs to the subgenus *Gomphus* as defined by Needham et al. (2000), who provided a key for all larvae of the subgenus except for the previously unknown larva of *G. sandrius*. Larvae of *Gomphus* are relatively difficult to identify because of similarity in form, intraspecific variability, and lack of a detailed comparative study of all species in the subgenus. Previous errors in association also account for some of the difficulty. For example, the larva of *Arigomphus lentulus* (Needham) was mistaken for *Gomphus militaris* Hagen by Bird (1934) and this error existed until Landwer and Sites (2003) corrected it. I associated larvae and adults of *G. sandrius* and herein provide the following description, illustrations, and diagnosis based on exuviae and other preserved larvae from several locations.

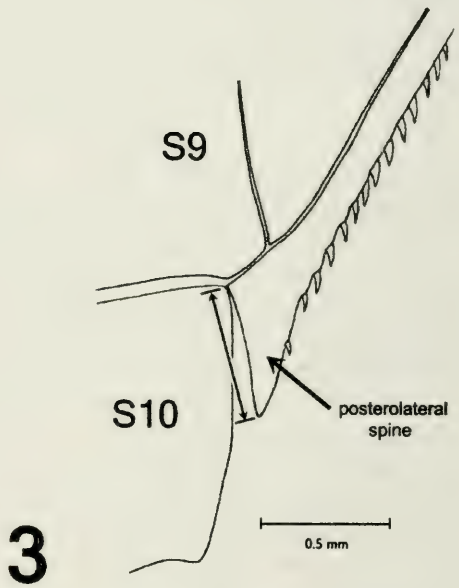
MATERIALS AND METHODS

I collected *Gomphus* larvae with an aquatic dip net in sand and gravel substrates of small, shallow tributaries in central Tennessee. Live individuals were transported to Florence, Alabama, and reared in an aerated aquarium. Specimens were preserved in 80% ethanol.

Morphological terminology follows that of Needham et al. (2000), except the apical tooth on the labial palp is called the end tooth, not end hook. Abdominal segments are abbreviated with an "S" preceding the







Figs. 1–3. 1, Map of central Tennessee showing known distribution of *Gomphus sandrius*. 2, Measuring "apical angle" (⊖) of abdomen in *Gomphus* larvae. 3, Measuring length of posterolateral spine of abdominal S9, ventral view.

number of the segment (e.g., S10 = abdominal segment 10). Measurements were taken with an ocular micrometer on a Wild stereomicroscope, making sure that each structure was perpendicular to my line of sight; a camera lucida was used to draw the figures. Length of antennal segment 3 was measured dorsomedially from base to apex. Length of hind tarsal claws was measured as a straight line (even though the claws are curved) from the dorsobasal notch to the apex. Cleaning with a fine brush was nec-

essary to count the serrations on the lateral margins of S6-S9 and to measure antennal segment 3. Length and width of S9 and S10 were measured ventrally. To quantify the degree of taper at the apex of the abdomen, I measured the angle formed by two lines drawn (using a camera lucida) from the anterolateral margins of S7 to the apex of the epiproct (Fig. 2); the resulting angle was designated as the "apical angle." The posterolateral spine of S9 was measured ventrally as shown in Fig. 3. The epiproct was measured dorsomedially; cercus length was measured along the dorsomedial margin. For the five characters in which *G. sandrius* and *G. graslinellus* were found to differ, I made no statistical comparisons, but calculated 95% confidence limits for the means using Microsoft Excel® (Table 1).

Final Stadium Larva of *Gomphus sandrius* (Figs. 4–9)

Description.—Based on 28 specimens (listed below). Body elongate and dorsoventrally flattened, general color pale brown with few dark markings, dorsum speckled with tiny raised dots and numerous, long, hairlike setae, abdomen lanceolate (Fig. 4). Total length 24.5–30.0 mm.

Head: Width 5.17–5.90 mm; rounded anteriorly, posterolateral corners slightly produced. Antennal segment 3 length 1.17–1.37 mm, 3.2–3.4 times longer than wide. Prementum 2.42–2.87 mm wide at distal margin, 2.71–3.20 mm long, lateral margins indented in basal third from which margins converge slightly to distal margin (Fig. 5), rarely parallel; ligula convex (Figs. 5 and 6a); palpal lobe incurved, end tooth usually slightly longer than adjacent tooth (Fig. 6a), sometimes twice as long (Fig. 6b).

Thorax: With dorsolateral, diagonal, dark brown stripes (Fig. 4). Apex of hind wing pad extending to apex of S4 or to anterior half of S5. Fore and middle tibiae with well-developed apical burrowing hook; hind femur length 4.9–5.7 mm, distal end extending nearly to posterior margin of S4 (Fig. 4); hind tarsal claw 0.83–0.93 mm long.

Abdomen: Widest at S5. Lateral spines on S6-S9 increasing in length posteriorly (Fig. 4), on S9 ranging from 0.53–0.77 mm long and extending to about midlength of S10. S2-S9 each with a middorsal posterior prominence, which on S3-S9 bears a distinct dorsal hook that overlies intersegmental membrane (Fig. 7). Posterior margins of terga 6–9 with stout spines, small and pale on S6, darker and more developed on S7-S9 (Fig. 8). S9 with middorsal, full-length, rounded ridge (Figs. 4, 8, 9), S8 with similar ridge on posterior half only. Lateral margins of S6-S9 appearing serrated due to small stout spines, numbering 0–4 on S6, 3–13 on S7, 9–18 on S8, and 16–28 on S9; distance between most serrations on S8 and S9 less than basal width of serrations. Width/length ratio of S9 ranging from 1.69 to 1.96; width/length ratio of S10 about 1.22–1.45. Apical angle (Fig. 2) 46–54° (mean = 50°). Epiproct 1.15–1.35 mm long, usually longer than cerci (1.03–1.21 mm) and paraprocts, occasionally shorter (Fig. 8); tips of cerci sharply acuminate, tips of paraprocts much more blunt than cerci.

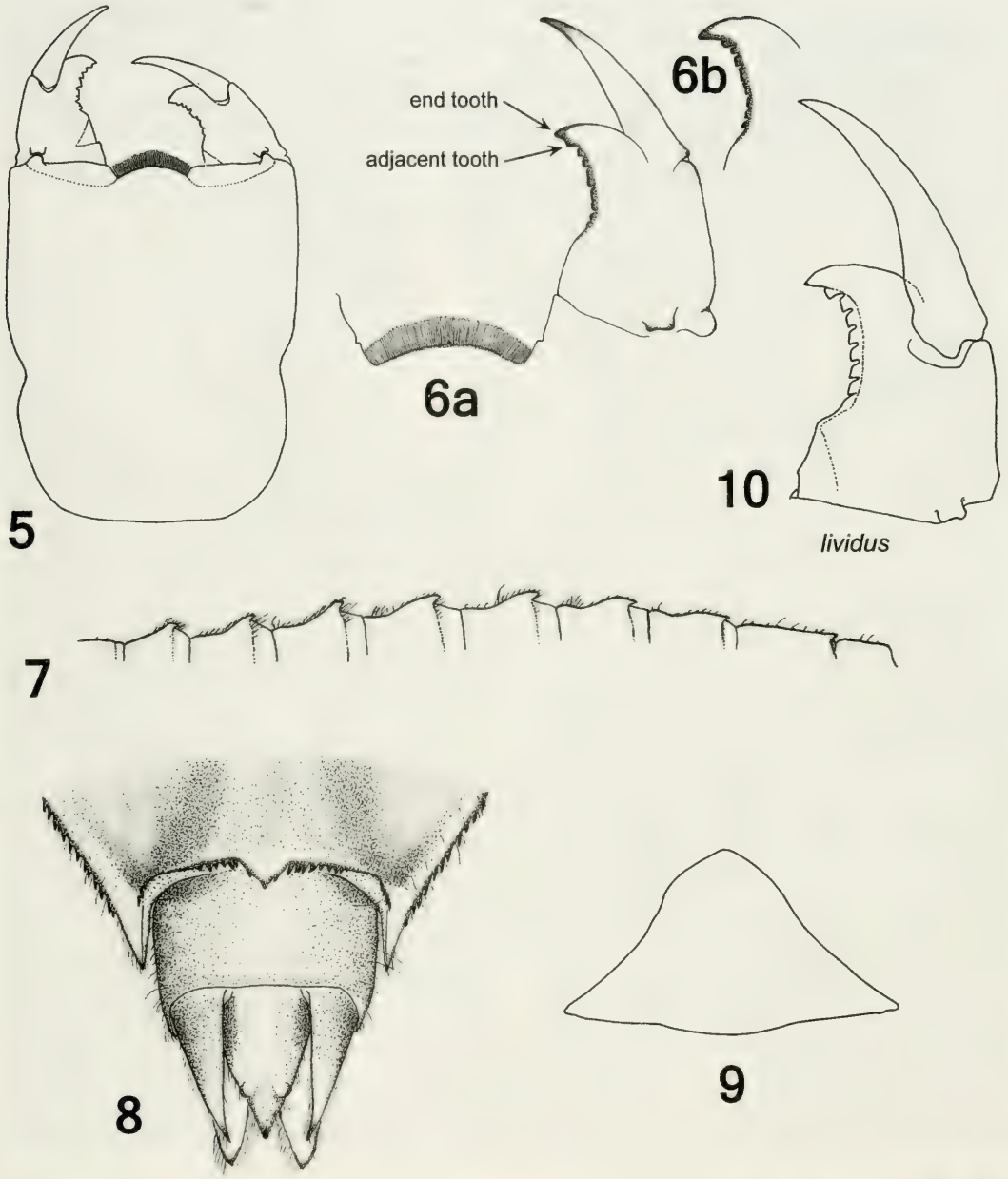
Specimens examined (n = 28).—TENNESSEE: *Bedford Co.*: Weakly Creek, Halls Mill Road, V-11–1983, KJT, 1 associated female exuvia, 3 unassociated exuviae; X-10-1083, 2 larvae, KJT; *Marshall Co.*: Wilson Creek, 3.2 km SE of Chapel Hill, V-11–1983, KJT, 5 exuviae; *Maury Co.*: Flat Creek, Hwy. 431, IV-26-1984, KJT, 1 associated male exuvia, 7 larvae; XI-4-1983, KJT, 4 larvae; *Rutherford Co.*, Middle Fork Stones River, near Elam Rd., I-15-2004, KJT, 4 larvae; *Wilson Co.*: Round Lick Creek, nr. I-40, III-4-1998, J. S. Tindell, 1 larva. All specimens are deposited in the Florida State Collection of Arthropods.

For comparative purposes, I examined 24 larvae/exuviae of each of the following: *G. exilis* Selys (AL, GA, NC, PA, SC, TN, WV, WI), *G. graslinellus* Walsh (AR, MO),

Fig. 4. *Gomphus sandrius* larva, dorsal aspect.

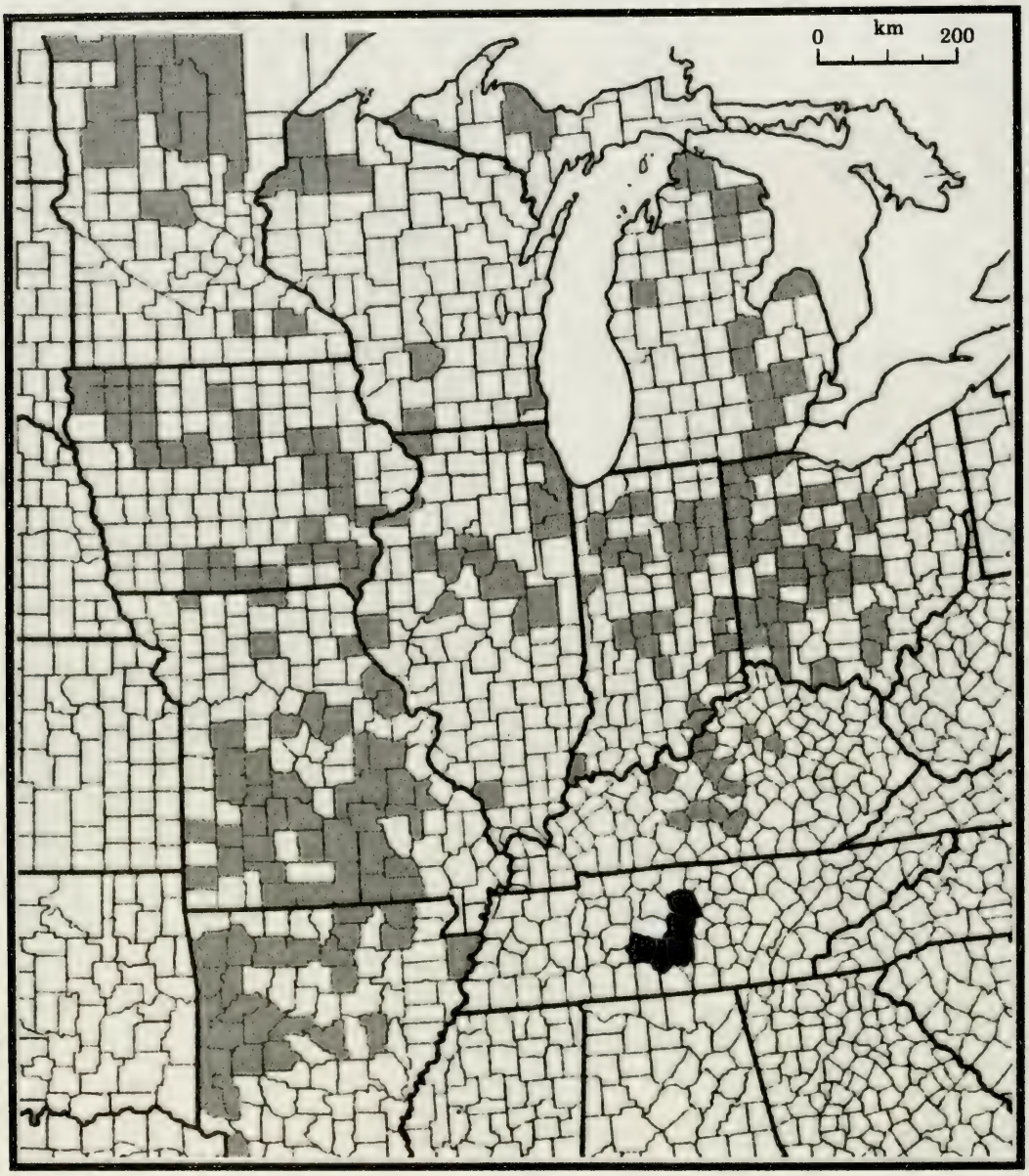
G. lividus Selys (AL, GA, MI, SC, TN, WI), and *G. minutus* Rambur (FL, GA).

Diagnosis.—In the larval key by Needham et al. (2000: 310–312), *G. sandrius* keys to *G. graslinellus* Walsh, a widespread species that is mainly Midwestern in distribution. These species are allopatric (see Donnelly 2004): the nearest record of *G. graslinellus* in Arkansas (Mississippi Co.) is roughly 270 km W of the westernmost *G. sandrius* record (Maury Co., TN), whereas the nearest *G. graslinellus* record



Figs. 5–10. 5–9, *Gomphus sandrius*. 10, *G. lividus*. 5, Prementum. 6a, Ligula and palpal lobe. 6b, Variation in palpal lobe. 7, Dorsal prominences of abdominal S2–9, lateral view. 8, Abdominal S9, S10 and anal appendages, dorsal view. 9, Abdominal S9 in cross-section. 10, Palpal lobe.

in Kentucky (Edmonson Co.) is about 120 km N of the northernmost *G. sandrius* record (Wilson Co., TN). Based on its presently known geographic range, it is possible that *G. graslinellus* occurs in western TN (Fig. 11). The larva is similar to *G. sandrius* in possessing a convex ligula, a variable but usually reduced end tooth on the palpal lobes, S9 much wider than long, and S9 with a full-length middorsal ridge. I



11

Fig. 11. Map of north-central U.S. showing distribution, by county, of *Gomphus graslinellus* (gray) and *G. sandrius* (black); note —*G. graslinellus* ranges further northwest of the area shown on the map.

compared larvae of these species based on 22 morphological characters and found significant differences in 5 characters (Table 1). The most reliable difference was length of antennal segment 3, as no overlap in range was found. Another useful character is the ratio of S9 width to length, as the confidence limits did not overlap with the

Table 1. Summary of five morphological characters for larvae of *Gomphus sandrius* and *Gomphus graslinellus*; measurements for antennal segment 3 length and hind tarsal claw length in mm (C.L. = confidence limits around the mean).

Character	Species	n	Mean	Range	95% C.L.
AntSeg3L	*G. sandrius*	24	1.27	1.17–1.37	1.25–1.29
	G. graslinellus	24	1.45	1.37–1.53	1.43–1.47
S9W/L	*G. sandrius*	24	1.82	1.69–1.96	1.79–1.85
	G. graslinellus	24	1.65	1.46–1.77	1.62–1.68
CercL/EpiL	*G. sandrius*	24	0.93	0.87–1.02	0.92–0.94
	G. graslinellus	24	0.86	0.80–0.93	0.85–0.87
PrementL/W	*G. sandrius*	24	1.13	1.09–1.19	1.12–1.14
	G. graslinellus	24	1.20	1.13–1.28	1.19–1.21
HindTarsClawL	*G. sandrius*	24	0.89	0.83–0.93	0.87–0.91
	G. graslinellus	23	0.99	0.89–1.05	0.97–1.01

range of either species. The confidence limits of 1) cercus length to epiproct length, 2) prementum length x width, and 3) hind tarsal claw length did not overlap; however, some overlap between the confidence limits and the ranges in these characters was found and therefore these characters are less reliable for differentiating *G. sandrius* and *G. graslinellus* larvae.

Three species of *Gomphus* (*Gomphus*) are recorded in Tennessee other than *G. sandrius,* namely *G. exilis* Selys, *G. lividus* Selys, and *G. quadricolor* Walsh. In *G. quadricolor,* S9 and S10 are about as wide as long (L/W ratio of S9 = 0.95–1.10, L/W ratio of S10 = 0.85–1.08), whereas in *G. exilis, G. lividus* and *G. sandrius,* S9 is much wider than long (range 1.23–1.96) and S10 is usually significantly wider than long (range 0.91–1.45).

Furthermore, *G. quadricolor* has small middorsal hooks only on S8 and S9, best seen in dorsal view; even though S2–7 are slightly prominent posteromedially, no dorsal hooks are present on these segments. *Gomphus sandrius, G. exilis*, and *G. lividus* are more likely to be confused with one another in Tennessee. *Gomphus lividus* is distinct from *G. sandrius* in the straight ligula (convex in *sandrius*), greater width of prementum (3.03–3.77 mm vs. 2.42–2.87 mm in *sandrius*), greater length of prementum (3.20–3.85 mm vs. 2.71–3.20 mm in *sandrius*), longer antennal segment 3 (1.49–1.89 mm vs. 1.17–1.37 mm in *sandrius*), longer hind tarsal claw (1.01–1.21 mm vs. 0.83–0.93 mm in *sandrius*), and longer S9 (2.79–3.36 mm vs. 2.17–2.62 mm in *sandrius*). *Gomphus exilis* has a narrower S9 (2.87–3.69 mm vs. 4.02–4.67 mm in *sandrius*), narrower S10 (1.15–1.44 mm vs. 1.56–1.78 mm in *sandrius*), and shorter cerci (0.87–1.01 mm vs. 1.03–1.27 mm in *sandrius*). Total length averaged less for *G. exilis* (23.3 mm) than for *G. sandrius* (27.5 mm), but both species are quite variable in size (*exilis* 21.0–26.0 mm vs. *sandrius* 24.5–30.0 mm). Other helpful differences are: *G. lividus* has more strongly curved palpal lobes (Fig. 10), *G. exilis* has fewer granulations on S9 (2–3 dozen vs. more than 6 dozen in *lividus* and *sandrius*), in *G. lividus* the diameter of the granules on S9 is at least twice that in *exilis* and *sandrius* (0.05–0.06 mm vs. 0.010–0.024 mm), *G. sandrius* has dorsal prominences on S2-S9 whereas *exilis* and *lividus* lack prominences on S2 and S3.

Gomphus sandrius is also morphologically similar to the allopatric *G. minutus* Rambur that occurs in much of FL and southern parts of GA, AL and SC (Donnelly 2004). The stout spines (serrations) on the lateral margins of S6–9 in *G. minutus* are very small and hidden by setae (difficult to detect even at 50× magnification), whereas these spines are larger and more easily detected (visible at 10×) in *G. san-*

drius (Fig. 8). The ratio of S9 width to length was much lower in *G. minutus* (1.20–1.39 vs. 1.69–1.96 in *sandrius*), as was the width/length ratio for S10 (0.83–1.00 vs. 1.19–1.45 in *sandrius*).

The tip of the abdomen in *G. sandrius* and *G. graslinellus* is more broadly tapered than in other members of the subgenus *Gomphus* (in *G. sandrius* mean apical angle = 50°, range 46–54°, in *G. graslinellus* mean = 49°, range 44–53°). Other broadly tapered species of the subgenus *Gomphus* had lesser values (*G. lividus* mean = 46°, range 42–50°, and *G. exilis* mean = 43°, range 40–51°). In this characteristic, *G. sandrius* is closest to species I measured in the subgenera *Gomphurus* (range 52–61°) and *Hylogomphus* (range 58–66°).

Remarks.—I found *Gomphus lividus* in two of the seven streams occupied by *G. sandrius* (Fall Creek in Bedford County, Middle Fork Stones River in Rutherford County). The microhabitats differed slightly: *G. lividus* larvae usually occupied slower edges where more silt/mud had accumulated, whereas *G. sandrius* larvae were usually in mixed gravel with less silt. I did not find *G. exilis* or *G. quadricolor* in any of the *G. sandrius* localities.

Acknowledgments

I thank Carl Cook (Center, KY), Dave Etnier (University of Tennessee), Brett Landwer (University of Missouri), and Bill Mauffray (Florida State Collection of Arthropods, Gainesville) for advice and specimen loans.

Literature Cited

Bick, G. H. 2003. At-risk Odonata of conterminous United States. Bulletin of American Odonatology 7(3): 41–56.

Bird, R. D. 1934. The emergence and nymph of *Gomphus militaris* (Odonata, Gomphidae). Entomological News 45: 44–46.

Donnelly, T. W. 2004. Distribution of North American Odonata. Part 1: Aeshnidae, Petaluridae, Gomphidae, Cordulegastridae. Bulletin of American Odonatology 7(4): 61–90.

Dunkle, S. W. 2000. Dragonflies Through Binoculars: A Field Guide to Dragonflies of North America. Oxford University Press, Oxford, 266 pp.

Landwer, B. H. P. and R. W. Sites. 2003. Redescription of the larva of *Gomphus militaris* Hagen (Odonata: Gomphidae), with distributional and life history notes. Proceedings Entomological Society of Washington 105(2): 304–311.

Needham, J. G., M. J. Westfall, Jr., and M. L. May. 2000. Dragonflies of North America. Scientific Publishers, Gainesville, 939 pp.